International Journal of Climate Research
2016 Vol. 1, No. 1, pp. 1-16
ISSN: 2690-2796
DOI: 10.18488/journal.112/2016.1.1/112.1.1.16

ANALYSIS OF FARMERS' VULNERABILITY, PERCEPTION AND ADAPTATION TO CLIMATE CHANGE IN KWARA STATE, NIGERIA

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ABSTRACT
The study examined farmers' vulnerability, perception and adaptation to climate change in Kwara State. Data were collected with the aid of structured questionnaire to elicit information from 120 food crop farmers selected through a multistage random sampling technique. Data were analyzed using descriptive statistics, fuzzy set approach and multinomial logit model. Results show that majority of the sampled farmers were in their productive age with about 26.6% had no formal education and were predominantly small scale farmers. The study revealed that majority (84%) of the farmers believed that temperature had increased while about 65.8% noticed that precipitation had declined. The farm household vulnerability assessment showed that the average multidimensional vulnerability indices for male and female farmers are 17.5% and 27.8%, respectively, while the average vulnerability index for all the farming households is 18.4%, implying that the intensity of vulnerability to climate change is higher in female farmers and that the whole sampled population is less than 50% vulnerability threshold. The econometric investigation revealed that education of household head, farming experience, land ownership, rainfall and temperature were the most relevant and significant factors that determined the farmers' choice of adaptation strategies to climate change in the study area. The major barriers to adaptation include lack of information on adaptation methods, land tenure problem and inaccessibility to credit.

Keywords: Perception, Adaptation, Vulnerability, Farm households, Climate change, Fuzzy approach.

Contribution/ Originality

The study contributes to the existing literature on climate change adaptations by taking into consideration the vulnerable poor farming households. The study adopted two methodologies to overcome the weakness of other studies. Gender attributes and their vulnerability intensity were investigated. The primary contribution is to guide strategy for future adaptations.

1. INTRODUCTION

The agricultural sector has gone through an evolution over the past decades when many new ideas were implemented and many new technologies were introduced. Producing more food for

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higher demand had become a continuous challenge around the globe, leading to food security problems in the medium and long terms. In the late 1960s and early 1970s, it was assumed that the growth of agricultural production would be unable to meet the world demand, but in the mid1970s world food production grew rapidly by using various newly introduced farming methods. Since the late 1980s, however, high food production raised new threat due to depletion of environmental and natural resources and land degradation. Climate change as defined by United Nation Framework Convention on Climate Change [1] refers to a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods. Climate change is expected to have serious environmental, economic, and social impacts. In particular, rural farmers, whose livelihoods depend on the use of natural resources, are likely to bear the brunt of adverse impacts. The extent to which these impacts are felt depends in large part on the extent of adaptation in response to climate change. Crop growth, soil water availability, soil fertility, pests and diseases and rise in sea level could be some effects of climate change.

Higher concentration of carbon dioxide in the atmosphere is expected to create a gradient that could facilitate increased intake of CO_2 and therefore increased rate of photosynthesis. This will be expected to produce higher yields of crops. A significant effect of climate change due to increased levels of CO_2 would be reflected in the production of both C3 crops (Cassava, Yam, cowpeas, wheat, soybeans, rice and potatoes) and C4 crops (millet, sorghum, sugar cane and maize) [2]. Also, expected changes in crop development and phenology can cause shortening or lengthening of crop cycle that could lead to decrease or increases in productivity. Sub-Sahara Africa has not been exempted from the impacts of climatic change regardless of her minimal contribution to worsening global climates. The region has been severely hit by effects of climatic change, including floods and droughts due to predominance dependency on rain fed agricultural production [3]. Agricultural production remains the main source of livelihoods for most rural communities in developing countries. In Africa estimates indicate that nearly 60-70 percent of the population is dependent on the agricultural sector for the employment, and the sector contributes on average nearly 34 percent to gross domestic product (GDP) per country [4]. Climate change will have greater negative impacts on poorer households as they have the lowest capacity to adapt to climatic change [5]. The threat that climate changes pose to agricultural production does not only cover the area of crop husbandry but also includes livestock and in fact the total agricultural sector. Evidence of the devastating effect of climate change on Nigerian agriculture in the past included the reported drought of 1972-73, in the northeastern Nigeria whereby about 300,000 animals, representing 13% of the livestock population of the region were reported to have died, while agricultural yield dropped to between 12% and 40% of the annual averages [6]. The effects of drought in terms of reduced food production are believed to have been even more severe between 1982 and 1984 than the 1972 – 73 periods. In some parts of Borno State, nearly 100% crop losses were recorded [7].

Vulnerability assessments in climate change studies can be traced back to earlier work on poverty mapping and food insecurity [8, 9]. Under this approach, the exposure units are usually geographical areas, the vulnerabilities of which are captured by the differences in their social, economic, institutional and environmental structure at a given point in time. According to Okunmadewa [10] vulnerability is the likelihood of a shock causing a significant welfare loss. He was of the opinion that vulnerability depends on exposure to risks (uncertain events that can lead to welfare loss) and on risk management actions taken to respond to risks, which may be ex-ante (before) or ex-post (after). Santiago [11] stated that vulnerability is the extent to which a natural or social system is susceptible to sustaining damage from climate change.

According to Bryant, et al. [12] studies have raised new research questions regarding how farmers perceive climatic change and variability; and also have identified those climatic properties that are of most importance to farmers in their decision making; and have suggested the types of adaptive responses that can be anticipated. Handmer and Dovers [13] opined that many regions and countries will be capable of adapting to climate change, but that poorer countries and regions will have difficulty responding to climate change. These authors argue that the study of adaptation to climate change should begin with the study of social and economic vulnerability.

Adaptation is an important component of climatic change impact and vulnerability assessment and is one of the policy options in response to climatic change impacts [14, 15]. The literature on adaptations has made it clear that adaptation are dependent on customs, institutions and policies; thus one might expect to see differences in the extent of adaption between agro-ecological zones within the same country.

Addressing long-term climate change should entail a comprehensive long-term response strategy at the national or local level and requires a dynamic approach [16]. However, in the absence of directed policy responses, farmers choose their own adaptation measures depending on their household and farm characteristics. The awareness of climate problems and the potential benefits of taking action is important determinant of adoption of agricultural technologies Hassan and Nhemachena [17]. Maddison [18] argues that farmer awareness of change in climate attributes (temperature and precipitation) is important to adaptation decision making. Adaptation is widely recognized as a vital component of any policy response to climate change. Studies show that without adaptation, climate change is generally detrimental to the agriculture sector; but with adaptation, vulnerability can largely be reduced [19, 20]. Though a few studies have been conducted to assess the impact of climate change on agriculture in Nigeria [2, 21-24] but few have examined the role of adaptation strategies. Thus the adaptation and mitigation measures that are available to policy makers are severely limited. This study aims to address this research gap by analyzing crop farmers' vulnerability, perception and adaptation to climate change in Nigeria.

Specifically the study sought to examine the socio-economic characteristics of crop farmers in the study area; assess the crop farmers' perception of climate variability and change; estimate farm household vulnerability to climate change and analyzing the factors that determine farmers' choice of adaptation strategies.

2. METHODOLOGY

2.1. Study Area

This study was carried out in Kwara State, Nigeria. Kwara state is bounded in the north by Niger State, in the south by Osun and Ondo states, in the east by Kogi and in the west by Oyo state with an international boundary with Benin Republic. It has a land area of about 32,500sq.km and population of about 2.6 million as at 2005 giving the state a population density of 96 persons per sq.km. The state is divided into four agricultural zones: zone A-Derived savannah Area (Baruteen, kaiama). Zone B-Flood plain Area (Pategi, Edu).

Zone C- Guinea Savannah (Asa, Moro, Ilorin West, Ilorin South, Ilorin East). Zone D-Rainforest area (Irepodun, Oyun, Offa, Isin, Ekiti, Ifelodun, Oke-Ero). It is made up of sixteen local government areas. The state is characterized by heavy rainfall with climate following usual tropical pattern. There are two main seasons; the rain season is from April to October while the dry season starts from November to March. The natural vegetation consists broadly of rain forest and wooded savannah. The annual rainfall ranges from 1,000-1,500mm, while maximum average temperatures range between 30°C and35°C. With this climatic pattern and sizeable expanse of arable and rich fertile soils, the vegetation, is well suited for the cultivation of a wide variety of food crops like; yams, cassava, maize, beans, rice, sugarcane e.t.c.

2.2. Sampling Technique

A multi stage sampling technique was employed to select respondents for this study. The state, sixteen local government areas are stratified into four zones (A, B, C, D) by the state's Agricultural Development Project (KWADP). The four zones formed the sample frame for the study. The second stage involves the selection of 5 villages from each of the four zones to represent the different agro climatic situations in the state. The last stage was the random sampling of six (6) food crop farmers based on the probability proportional to size in the 20 villages selected. Thus, a total sample of 120 respondents was selected for this study.

Open-ended questions were asked farmers whether they had noticed long-term changes in temperature, rainfall, effect of these changes if noticed on crop production and the coping strategies adopted by farmers in response to these effect. However, this study used principally the section of the survey on socio-economic characteristics, perceptions of climate change, adaptations made by farmers, and barriers to adaptation. Climate data recorded at meteorological stations were collected from Kwara Agricultural Development Project weather survey, 1988-2009.

2.3. Data Analysis

A combination of analytical tools was employed in the study. These include Descriptive Statistics, Fuzzy Set Approach and Multinomial Logit (MNL) Model.

2.3.1. Descriptive Statistics

The socio-economic data of farmers were described using mean, standard deviation, frequency and percentage distribution.

2.4. Model Specification

2.4.1. Fuzzy Set Approach

Indices of vulnerability of farmers to climate change were computed using the Fuzzy Set theory originally developed by Zadeh [25]. This approach had been widely applied to poverty analysis by authors like [26-31]. Zadeh [25] characterized a fuzzy set as a class with a continuum of grades of membership. Following Oyekale, et al. [32] who estimated vulnerability using the fuzzy set earlier applied by Costa [30] to multidimensional analysis, this study used the same approach. It can be expressed that given a population A of n households, A = (a1, a2, a3 …an), the subset of households that are vulnerable B includes any household aiεB. These households present some degree of vulnerability in at least one of the m attributes of X. The vulnerability attributes to be considered in this study are: type of housing, land ownership, source of water, access to health care facility, access to education, access to radio, television, handset, owned a car/truck, owned a motor cycle, access to credit, production system, water for irrigation, planting of improved variety and access to market. The degree of membership to the vulnerable household by the i-th household (i=1,….,n) with respect to a particular attribute j given that (j = 1,……,m) is defined as: $\mu B\,[Xj\ (ai)] = xij,\ 0 \leq xij \leq 1$.

Specifically,

(i) xij = 1 if the i-th household possesses the j-th attribute that tends to increase vulnerability;

(ii) xij = 0 if the i-th does not possess the j-th attributes such that vulnerability decreases;

(iii) 0≤ xij≤ 1if the i-th household possesses the j-th attributes with an intensity belonging to the open interval (0, 1).

Betti Cheli and Gambini [33] noted that putting together categorical indicators of deprivation for individual items to construct composite indices requires decisions about assigning numerical values to the ordered categories and the weighting and scaling of the measures. Individual items indicating non-monetary deprivation often take the form of simple 'yes/no' dichotomies. In this case xij is 0 or 1. However, some items may involve more than two ordered categories, reflecting different degree of deprivation. Consider the general case of c = 1 to C ordered categories of some deprivation indicator, with c = 1 representing the most deprived and c = C the least deprived situation. Let ci be the category to which individual *i* belongs. Cerioli and Zani [26] assuming that the rank of the categories represents an equally-spaced metric variable, assigned to the individual a deprivation score as:

Xij = (C-ci)/(C-1) where 1 ≤ ci ≤C. Therefore, xij needs not to be compulsorily 0 or 1, but 0 ≤ xij ≤ 1 when there are many categories of the jth indicator and the household possesses the attribute with intensity. The vulnerability level of the i-th household μB (ai), which implies the degree of membership the i-th household to the set of B is defined as the weighted average of xij,

$$\mu B(ai) = \sum_{j=1}^{m} xij\ wj / \sum_{j=1}^{m} wj$$

Where wi is the weight attached to the j-th attribute.

The vulnerability index μB (ai) measures the degree of vulnerability of the i-th household as a weighing function of the m attributes. The weight wj attached to the j-th attributes stands for the intensity of vulnerability of Xj. It is an inverse function of the degree of deprivation of this attribute by the population of households. The smaller the number of households and the amount of vulnerability of Xj, the greater the weight wj. A weight that fulfills the above property is proposed by Cerioli and Zani [26] and can be represented with the following expression:

$wj = \log[n/\sum_{i=1}^{n} xijni] \geq 0$

With $\sum_{i=1}^{n} xij\ ni > 0$ and where ni is the weight attached to the ith sample observation when the data are extracted from sample survey.

Finally, the vulnerability ratio of the population μB is simply obtained as a weighted average of the vulnerability ratio of the i-th household μB(ai):

$$\mu B = \sum_{i=j}^{n} \mu B(ai)ni / \sum_{i=1}^{n} ni$$

The contribution of each indicator to vulnerability level can be decomposed as:

$$\mu B = \sum_{j=1}^{m} \mu B(Xj)wj / \sum_{j=1}^{m} wj$$

2.4.2. The Multinomial Logit (MNL) Model

The multinomial logit (MNL) model was used to analyze the determinants of farmers' choice of adaptation strategies. This method can be used to analyze crop [34] and livestock [35] choices as methods to adapt to the negative impacts of climate change. The advantage of the MNL is that it permits the analysis of decisions across more than two categories, allowing the determination of choice probabilities for different categories Wooldridge [36]. Moreover, Koch [37] emphasizes the usefulness of this model by describing the ease of interpreting estimates from this model. To describe the MNL model, let *y* denote a random variable taking on the values {1, 2...*J*} for *J* , a positive integer, and let ***x*** denote a set of conditioning variables. In this case, *y* denotes adaptation options or categories and ***x*** contains household attributes like sex, age, education, farming experience, farm size, and land ownership. The question is how cetirus paribus changes in the elements of ***x*** affect the response probabilities $P(y = j / x)$, $j = 1, 2 \ldots J$. Since the probabilities must sum to unity, $P(y = j / x)$ is determined once we know the probabilities for $j = 2 \ldots j$. Let x be a 1× k vector with first element unity. The MNL has response probabilities:

$$P(y=j / x) = \exp(x\beta j) / [1+\sum_{h=1}^{j} \exp(x\beta h),\ j = 1 \ldots j] \quad \text{equation (1)}$$

Where βj is k×1, j = 1…….j

Following [34, 35, 38] the adaptation options for this study was selected. These are Soil conservation, planting of improved variety, changing planting date, Diversification to non-farm activity, changing farm size. The adaptation methods for this study are based on asking farmers about their perceptions on climate change and the actions they take to counteract the negative impact of climate change. The explanatory variables for this study include: education of the head of the household, farm size, gender of the head of the household, land ownership, farming experience, temperature and rainfall. Differentiating equation (1) with respect to the explanatory variables provides marginal effects of the explanatory variables given as:

$$\frac{\partial pj}{\partial xk} = pj(\beta jk - \sum_{j=1}^{j-1} pj\beta jk)$$

The marginal effects or marginal probabilities are functions of the probability itself and measure the expected change in probability of a particular choice being made with respect to a unit change in the independent variable from the mean [37, 39].

3. RESULTS AND DISCUSSION

3.1. Socioeconomic Characteristics of the Respondents

Table 1 showed that farmers in the study area were predominantly male, representing 91 percent of the total respondents while the remaining 9% were female. Majority (95.8%) of the sampled population were married with about 46.7% fall between the ages of 30-50 years which is the productive age of an individual according to the life cycle hypothesis. The mean age of the sampled farmers is 47 years. Educational status of respondents revealed that 26.6 percent of the sampled farmers had no formal education, while 35.8%, 29.2% and 8.3%t of the respondents had primary, secondary and tertiary education respectively. The table revealed further that 37.5% of the respondents had farming as their primary occupation while 50.8% are traders as well as farmers and 11.7% are civil servants as well as farmers. This implies that a higher proportion of the farmers engaged in more than one income generating activity. Also, the majority of the sampled farmers (89.2%) is small scale farmers.

Table-1. Socio-economic characteristic of farmers

Variables	Frequency	Percentage
Gender		
Male	109	90.8
Female	11	9.2
Marital Status		
Single	5	4.2
Married	114	95.8
Age		
30 – 39	16	13.3
40 – 49	56	46.7
50 – 59	43	35.8
Above 60	5	4.2
Educational level		
No formal Education	32	26.6
Primary	43	35.8
Secondary	35	29.2
Tertiary	10	8.3
Primary Occupation		
Farming	45	37.5
Trading	61	50.8
Civil Servant	14	11.7

Farming Practices		
Small scale	107	89.2
Medium/large scale	13	10.8

Source: Field survey, 2010.

3.2. Farmers' Perceptions of Climate Change

3.2.1. Perception of Changes in Temperature

The analysis of farmers' perception on temperature changes presented in Table 2 indicates that 84% of the respondents' perceived increase in temperature and about 16% noted irregular changes in temperature. The responses from the farmers are in line with the statistical record of temperature data from the Kwara Agricultural Development Project Weather Survey between 1988 and 2009 (Fig 1) which shows an increasing trend.

Table-2. Perceptions on changes in temperature

Perception on Temperature	Frequency	Percentage
Increased	101	84.0
Irregular	19	16.0
Total	120	100.0

Source: Field survey 2010.

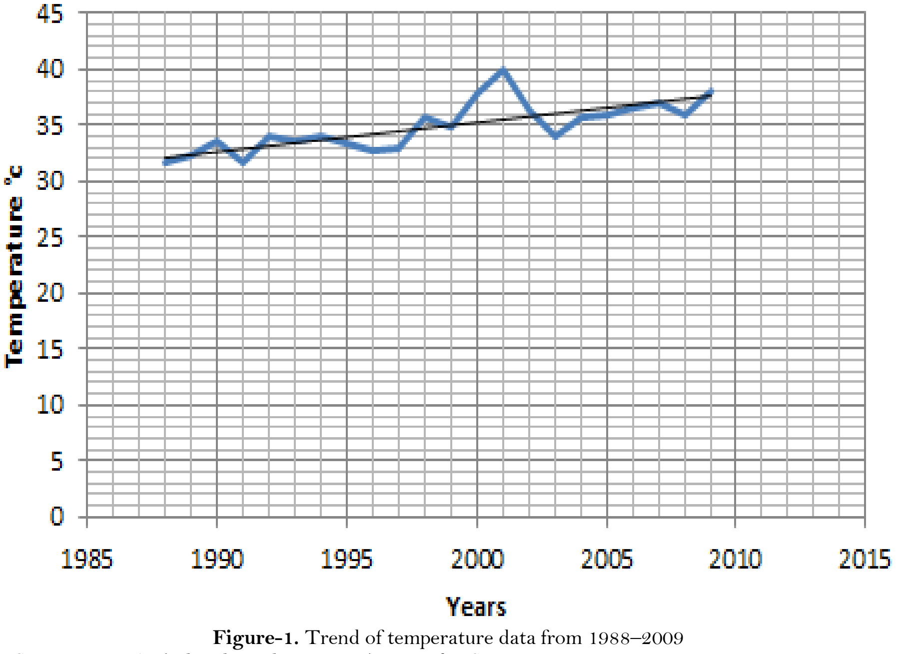

Figure-1. Trend of temperature data from 1988–2009

Source: Kwara Agricultural Development Project Weather Survey, 1988 – 2009.

3.2.2. Perceptions of Changes in Rainfall

Farmers' perception of changes in rainfall is presented in Table 3. Result indicates that almost all the respondents observed changes in rainfall patterns over the past years. About 66% noticed a decrease in the amount of rainfall or a shorter rainy season, 33% noticed irregular changes in the total amount of rainfall and also in the timing of the rains. This implies that most of the farmers in this study are aware of the fact that the level of precipitation is declining. The responses from the farmers are also in line with the report by the Kwara Agricultural Development Project Weather Survey, 1988-2009 (Fig. 2) which depicted a decreasing trend in precipitation.

Table-3. Perceptions on changes in rainfall

Perception on Rainfall	Frequency	Percentage
Increased	1	0.8
Reduced	79	65.8
Irregular	40	33.3
Total	120	100.0

Source: Field survey 2010.

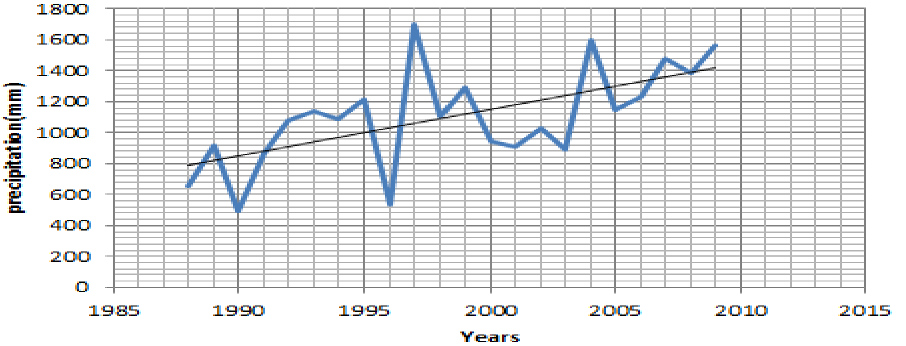

Figure-2. Trend of rainfall data from 1988-2009

Source: Kwara Agricultural Development Project Weather Survey, 1988 – 2009

3.3. Assessment of Farm Households' Vulnerability using Fuzzy set Approach

Table 5 shows the farmers' vulnerability assessment in the study area. In order to compute the indices of vulnerability of farm household to climate change, 15 indicators of vulnerability attributes were identified: type of housing, land ownership, source of water, access to health care facility, access to education, access to radio, television, handset, owned a car/truck, owned a motor cycle, access to credit, production system, water for irrigation, planting of improved variety and access to market. The results in table 4, shows that 93.5% of male respondents had their vulnerability indices < 0.3(30 percent), as against 45.5% of a female farmers. The most vulnerable male farmer have average vulnerability index of 34.3% as against 46.5% for most vulnerable female farmer. Average multidimensional vulnerability indices for male and female farmers are 17.5% and 27.8% respectively. Average vulnerability index for all the farming household is 18.4%. This indicates that the percentage of vulnerable household is higher among female farmers. If we take 18.4 percent (average multidimensional vulnerability index) as the vulnerability line, the multidimensional vulnerability incidence of male and female farmers are 47.71% and 81.82% respectively. This implies that the intensity of vulnerability is higher with female farmers. The computed t- statistics (3.916) from Levene's test of equality of variance shows that the mean difference by gender is highly significant at 1 percent level (p<0.01).

Table-4. Household Vulnerability using Fussy set Approach

Vulnerability range	Male		Female		All	
	Frequency	Average vulnerability index	Frequency	Average vulnerability index	Frequency	Average vulnerability index
0.00<0.1	15	0.058	1	0.077	16	0.059
0.1<0.2	55	0.147	4	0.177	59	0.149
0.2<0.3	32	0.238	0	0	32	0.238
0.3<0.4	7	0.343	4	0.335	11	0.340
0.4<0.5	0	0	2	0.465	2	0.465
Total	109	0.174	11	0.278	120	0.184

Source: Field survey 2010.

Table-5. T-test of significance between the vulnerability of male and female farm household

Variance	Levene's test of equality of variance				
	F	Sig	T	Df	Sig. (2-tailed)
Equal variance assumed	9.835	0.002	3.916	118	.000
Equal variance not assumed			2.591	10.733	.026

Source: Field survey 2010.

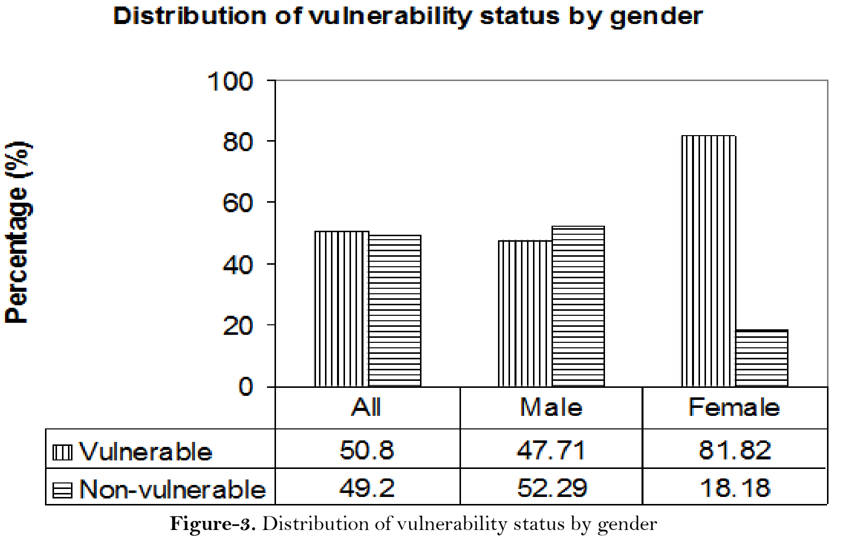

Figure-3. Distribution of vulnerability status by gender

Source: Field survey, 2010

3.4. Determinants of Farmers' Choice of Adaptation Strategies

The choice of farmers' adaptation strategies was estimated using multinomial logit (MNL) model. MNL was estimated by normalizing one category which is normally referred to as the reference category. In this analysis, no adaptation option was used as the reference category. The estimated coefficient of the MNL and their level of significance are presented in Table 6.

Table 7 shows the absolute partial changes in the six probability choices after marginal changes in the independent variables. The maximum likelihood estimation (an iterative procedure) for the fitted model of the multinomial logit was -174.33675. The likelihood ratio chi-square value is 73.70 and is significant at 1 percent. Multinomial logit model results in table 6 revealed the odds of using different adaptation techniques by farmers while table 7 presents the marginal effects of independent variables on the adaptation techniques adopted by the farmers. The coefficient of the probabilities of adaptation of the six adaptation options were estimated with respect to the no adaptation category.

Result shows that for farmers to adopt soil conservation techniques, farmers' experience in farming, perception on rainfall and temperature were the signification factors. The marginal effect shows that a year increase in farming experience would increase the use of soil conservation by 0.006 unit. Also a unit increase in temperature would result in 0.011 increases in the use of soil conservation respectively. Similarly, a unit increase in rainfall would decrease the use of soil conservation by 0.566. The probability of adopting soil conservation falls with more precipitation in every season except dry season. With more rain, farmers can grow crops without soil conservation technique, making the cost unnecessary. This implies that soil conservation technique is adopted mostly during the period of warming to cushion the harmful effect on crops. The result corroborates the findings by Hassan and Nhemachena [40] that experienced farmers have high skills in farming techniques and increased likelihood of using portfolio diversification as well as spread risk among activities.

Also, the choice of planting improved variety by the farmers as an adaptation option showed that education of the household head, farming experience, perception on rainfall and temperature are all positive and significant factors. Findings showed that by increasing these factors by one unit respectively, would increases the probability, choosing improved variety by 0.004, 0.002, 0.014 and 0.013, respectively

Changing planting dates as an adaptation option showed that education, farming experience, rainfall, temperature and land ownership were the relevant and significant factors. The marginal effects showed that increasing these factors by one unit respectively, increases the probability of selecting, changing crop planting dates by 0.003, 0.015, 0.224, 0.192 and 0.125, respectively.

Adaptation to climate change by diversification to non-farm activity revealed that farmers' educational level is the only relevant and significant factor that influences the choice of this adaptation option. A year increase in the education of the household head increases the probability of adopting diversification to non-farm activity by 0.014 unit. According to Gbetibouo [41] farmers' engagement in off-farm employment may serve as a proxy for the amount of time available for farming activities. Therefore, households with more off-farm income may have the likelihood of adopting other additional strategies to cope with changing climatic conditions.

Also, the choice of adaptation to climate change by changing the use of farm size showed that farmers' experience in farming and land ownership are the relevant and significant factors. The result showed that a year increase in farming experience and a unit increase in hectare of land owned increases the probability of adaptation to climate change through changing the use of farm size by 0.0201 and 0.0375 unit respectively. This result is in agreement with the findings by Gbetibouo [41] who argue that farmers with proper property rights may be able to change their amount of land under cultivation to adjust to new climatic conditions.

3.5. Barriers to Adaptation

The analysis of barriers to adaptation to climate change in the study area is presented in Table 8. Results show that there are five major constraints to adaptation. These are lack of information, inaccessibility to credit, shortage of labor, shortage of land, and poor potential for irrigation. Most of these constraints are associated with poverty. For instance, lack of information on appropriate adaptation options could be attributed to the dearth of research on climate change and adaptation options in the study area. Inaccessibility to credit hinders farmers from getting the necessary resources and technologies that facilitate adaptation to climate change. Adaptation to climate change is costly and the need for intensive labour use may contribute to this cost. Thus, if farmers do not have sufficient family labour or the financial means to hire labor, it will hinder their adaptive capacity. This result is in line with argument which assumes that large family size is normally associated with higher labour endowment, which would enable a household to accomplish various agricultural tasks [42]. Shortage of land has been associated with high population pressure, which forces farmers to intensively farm a small plot of land and makes them unable to prevent further damage by using practices, such as planting trees that compete for agricultural land. Poor potential for irrigation is most likely associated with the inability of farmers to use the water that is already there, due to technological incapability. Farmers in the study area are generally poor and cannot afford to invest in irrigation technology that can sustain their livelihoods during harsh climatic conditions.

Table-6. Parameter estimates from the multinomial logit climate change adaptation model

Independent variable	Soil Conservation	Planting of improved variety	Changing planting dates	Diversification to non-farm activity	Changing the use of farm size
Gender of household head	1.272 (0.241)	1.682 (0.992)	0.871 (0.237)	.1890 (0.784)	0.902 (0.324)
Age of household head	0.035 (0.621)	-0.063 (0.395)	0.013 (0.739)	0.007 (0.836)	-0.030 (0.519)
Education	-0.013 (0.841)	0.020*** (0.000)	0.096*** (0.008)	0.059* (0.110)	-0.053 (0.270)
Farming experience	0.192* (0.066)	0.208** (0.048)	1.031* (0.058)	0.018 (0.719)	0.475** (0.020)
Farm size	-0.660 (0.376)	0.456 (0.394)	0.062 (0.228)	0.480 (0.342)	0.008 (0.58)
Rainfall	-0.250* (0.006)	0.029*** (0.000)	0.001** (0.020)	-.833 (0.275)	-0.275 (0.438)
Temperature	.223** (0.042)	0.445*** (0.000)	0.012** (0.035)	0.149 (0.846)	-0.190 (0.846)
Land ownership	1.620 (0.996)	0.364 0.270)	0.504* (0.107)	-0.087 (0.765)	1.815*** (0.003)

Source: Field survey 2010.
Note;*** significant at 1%, ** significant at 5%, and * significant at 10% probability level, respectively.*odd-ratio in parentheses

Table-7. Marginal effects from the multinomial logit climate change adaptation model

Independent variable	Soil Conservation	Planting of improved variety	Changing planting dates	Diversification to non-farm activity	Changing the use of farm size
Gender of Household head	0.028 (0.296)	0.016 (0.315)	0.021 (0.269)	0.043 (0.351)	0.095 (0.237)
Age of household head	0.011 (0.235)	-0.002 (0.273)	0.024 (0.416)	0.002 (0.213)	-0.004 (0.365)
Education	-0.003 (0.320)	0.004*** (0.001)	0.003** (0.015)	0.014 *** (0.0032)	-0.007 (0.226)
Farming experience	0.006*** (0.012)	0.002* (0.146)	0.015*** (0.009)	0.004 (0.332)	0.020 ** (0.036)
Farm size	-0.040 (0.270)	0.097 (0.235)	0.255 (0.381)	0.114 (0.205)	0.038 (0.273)
Rainfall	-0.566** (0.029)	0.014*** (0.000)	0.224** (0.042)	-0.021 (0.376)	-0.057 (0.395)
Temperature	0.011* (0.066)	0.013*** (0.001)	0.192* (0.066)	0.011 (0.976)	-0.063 (0.275)
Land ownership	1.210 (0.394)	0.077 (.493)	0.125** (0.027)	-0.021 (0.227)	0.038* (0.135)

Source: Field survey, 2010.
Note;*** significant at 1%, ** significant at 5%, and * significant at 10% probability level, odd ratio in parentheses.
Reference category: No adaptation; Number of observations: 120; Log likelihood function: -174.33675, Chi-squared: 73.70; Degrees of freedom: 45; Significance level 0.0044

Table-8. Barriers to adaptation

Barriers to Adaptation	Frequency	Percentage
Shortage of labour	17	14.2
Inaccessibility to credit	96	80.0
Shortage of Land	24	21.7
Poor potential for irrigation	51	42.5
Lack of information	69	57.5

Source: Field survey 2010.

4. CONCLUSSION

The study revealed that farmers recognized the fact that temperatures is increasing and rainfall is decreasing. Although farmers were aware of climatic changes, few seem to taken steps to adjust their farming activities to account for the impacts of climate change. Crop farmers' vulnerability to climate change indicates that farmers were highly vulnerable, especially to declining rainfall and increased temperature. The determinants of farmers' choice of adaptation strategies to climate change are education, farming experience, perception on rainfall, temperature and land ownership. The results revealed that lack of information on climate change, inaccessibility to credit, shortage of labor, shortage of land, and poor potential for irrigation are the major factors that hindered the effective adaptive capacity of crop farmers to climate change.

4.1. Policy Recommendations

In order to reduce the adverse effect of climate change and increase farmers' productivity, government policies should be directed towards:

- Raising awareness of climate change through agricultural extension officers and media
- Increased farmers access to affordable credit through the establishment of various loan scheme at low interest rate
- Research and development of new crop varieties that suited to drier conditions.
- Investment in irrigation technology to cushion the effect harsh weather on crops.

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